# Systematic Review

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# Active Video Games for Improving Physical Performance Measures in Older People: A Meta-analysis

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## ABSTRACT

**Background and Purpose:** Participation in regular physical activity is associated with better physical function in older people (>65 years); however, older people are the least active of all age groups. Exercise-based active video games (AVGs) offer an alternative to traditional exercise programs aimed at maintaining or enhancing physical performance measures in older people. This review systematically evaluated whether AVGs could improve measures of physical performance in older people. Secondary measures of safety, game appeal, and usability were also considered.

**Methods:** Electronic databases were searched for randomized controlled trials published up to April 2015. Included were trials with 2 or more arms that evaluated the effect of AVGs on outcome measures of physical performance in older people.

**Results:** Eighteen randomized controlled trials (n = 765) were included. Most trials limited inclusion to healthy community-dwelling older people. With the exception of 1 trial, all AVG programs were supervised. Using meta-analyses, AVGs were found to be more effective than conventional exercise (mean difference [MD], 4.33; 95% confidence intervals [CIs], 2.93-5.73) or no intervention (MD, 0.73; 95% CI, 0.17-1.29) for improving Berg Balance scores in community-dwelling older people. Active video games were also more effective than control for improving 30-second sit-to-stand scores (MD, 3.99; 95% CI, 1.92-6.05). No significant differences in Timed Up and Go scores were found when AVGs were compared with no intervention or with conventional exercise.

**Conclusions:** Active video games can improve measures of mobility and balance in older people when used either on their own or as part of an exercise program. It is not yet clear whether AVGs are equally suitable for older people with significant cognitive impairments or balance or mobility limitations. Given the positive findings to date, consideration could be given to further development of age-appropriate AVGs for use by older people with balance or mobility limitations.

**Key Words:** aged, exercise, older adult, video games

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*The authors declare no conflicts of interest.*

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## INTRODUCTION

Physical activity levels have been shown to decline with advancing age,[1,2] yet regular participation in physical activity among older people (≥65 years) is associated with a reduced risk of cardiovascular and cardiometabolic disease, better physical fitness, and physical function.[3-6] However, adults aged 70 to 85 years are reported to be the least active of all age groups.[7]

Active video games (AVGs), where the person is required to move to play the game, were first used to encourage activity in children,[8,9] but they also show potential for encouraging activity in older people.[10,11] Motivators to being active identified by older people include enjoyment and social interaction, as well as the perceived health benefits.[12-14] A key attribute of AVGs is the immediate visual and auditory feedback on the player's performance, which is fun and motivating. In addition, the range of games, dance, and formal exercise programs available caters for individual preferences.

Active video games increase energy expenditure, with energy expended playing AVGs by older adults equivalent to light-to-moderate intensity activity.[15-17] Perhaps more important is the ability to incorporate various motor control challenges into AVGs to improve balance and lower limb function, which are considered important for reducing falls risk and maintaining independence.[18,19]

Randomized controlled trials (RCTs) have begun to evaluate the effect of AVGs on physical function measures in older people. However, on the basis of narrative synthesis of 13 RCTs, 1 systematic review concluded that there was insufficient evidence to support the effectiveness of AVGs for improving physical function in older people.[20]

The objective of the current systematic review was to provide an updated analysis of RCTs that have used AVGs to improve physical function in older people, using meta-analyses where appropriate to increase the power of findings from the individual trials. This review also considered safety, game appeal, and usability aspects of AVGs for older people.

## METHODS

### Data Source and Search Strategy

Randomized controlled trials identified up to April 2015 were sourced from the following electronic databases: MEDLINE (OvidSP), Scopus, and the Cochrane Library (Wiley). Search terms combined the following subject headings and key words, formatted according to the requirements for each database: "Wii" *or* "Xbox*" *or* "Video games" *or* "Virtual" rehabilitation" *or* "Interactive video game" *or* "Virtual reality" *and* "Elderly" *or* "Old*" *or* "Senior" *and* "Physical activity" *or* "Exercise" *or* "Balance."

### Selection Criteria

Inclusion criteria were RCTs that compared exercise-based AVGs in older people with no intervention or usual care, traditional exercise or placebo, with outcomes that objectively measured physical performance (ie, balance, mobility or physical performance test batteries), or subjectively measured physical performance (ie, activity or balance confidence questionnaires).

Trials that used off-the-shelf, modified off-the-shelf or purpose-designed AVGs, offered over any length of time with the aim of improving physical performance measures were eligible.

The majority (>50%) of participants needed to be older adults (>65 years), living in the community, long-term care (rest home, nursing home, residential care, assisted living, and veteran's hospital), or acute hospital settings. Trials of AVGs targeting individuals with specific conditions (eg, stroke or diabetes) were excluded.

### Data Extraction

Two review authors (LT, TF) independently screened the titles identified in the initial search to exclude those that were obviously outside the scope of the review. The same 2 authors then independently reviewed the abstracts of the remaining records. Where it was unclear from the abstract whether the study was relevant, the full article was reviewed. Characteristics of included trials were summarized according to population, intervention, comparator, and outcome characteristics.

The methodological quality was assessed independently by the same 2 authors (LT and TF) using the Cochrane Collaboration's risk of bias tool.[21] Items were scored as high risk, low risk, or unclear risk of bias using the tool's set criteria. Consensus was reached on any item where there was any discrepancy between the 2 reviewers' evaluations.

Where trial outcome measures were the same and study group characteristics similar, studies were pooled and meta-analysis undertaken using Review Manager (Revman) software (Version 5.2). Effect sizes for outcomes were expressed using the mean difference (MD) and 95% confidence intervals (CIs). For each trial included in the meta-analyses, the MD was calculated using change from baseline scores for control and experimental groups. Standard deviations for the MD were calculated according to the protocol described in the *Cochrane Handbook for Systematic Reviews*.[22] The $I^2$ statistic was used to measure statistical heterogeneity. Where $I^2$ was 50% or less, the fixed-effects model was used. Where $I^2$ was more than 50, the more conservative random-effects model (REM) was used.

## RESULTS

### Included Studies

Eighteen RCTs met the eligibility criteria for the review (n = 765) (Figure 1). Studies were conducted in 9 countries: Australia (3), the United States (6), Denmark, Japan, Korea, Taiwan, France (2), Canada and Switzerland (2). A summary of population, intervention, comparator, and outcome characteristics is listed in Table 1.

Seven trials compared AVGs with no intervention[25,30,33,36-38] or usual care[32]; 5 trials compared AVGs with conventional exercise (ie, strength, balance, mobility, and/or balance exercises that did not use video game technology)[28,29,31,35,39] and 3 trials compared AVGs with both conventional exercise and a no intervention control.[26,34,40] The remaining trial compared AVGs with a placebo shoe insole.[27]

### Risk of Bias

Four of the 18 trials were assessed as low risk of bias across 3 or more of the 6 items assessed.[27,28,38,39] The remainder had 4 or more items assessed as either high or unclear risk because there was insufficient information reported for evaluation (Table 2).[23-26,30-32,33-37,40]

For all outcomes analyzed, there was no indication that outcome measures were influenced either positively or negatively by the risk of bias scores.

### Intervention Characteristics

The duration of AVG programs for community dwellers was 3 to 20 weeks, with most offered for 8 weeks, usually 2 to 3 times weekly for approximately 40 minutes each

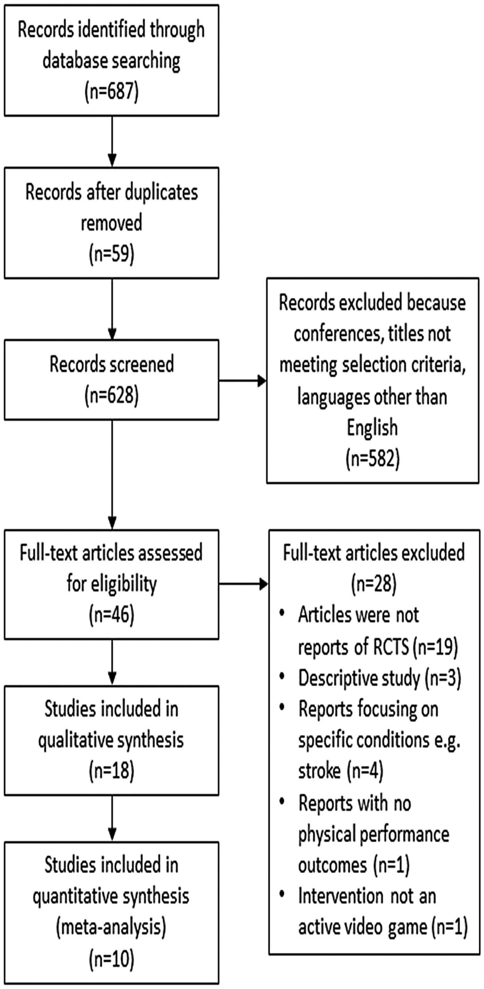


**Figure 1.** Study selection flow diagram.

session. For hospitalized older people, the program ran daily for the duration of the patient's stay (usually 7 days).

With the exception of 1 trial, delivered in the home environment,[38] all trials were supervised programs conducted in a gymnasium or research center setting. Most were delivered on an individual basis, although 2 trials used either game play with a partner[30] or in small groups.[31]

Eleven trials used Nintendo Wii,[23,24,26-30,34-36,40] 5 used pressure-sensitive mat systems,[25,31,33,38,39] 1 used the Kinect motion sensor,[37] and the remaining trial used a virtual reality head set.[32]

The focus of all trials except 1[30] was to improve balance. Nine trials used solely AVGs.[23-25,28,30,34,37-39] Eight trials combined the AVGs with conventional exercise to develop balance, strength, or aerobic capacity.[26,27,29,31-33,35,36] One 3-arm trial compared AVGs alone with exercise alone and a third intervention group that combined AVGs with exercise.[40]

There was no clear indication that trials that combined exercise and AVGs programs had better or worse outcomes and trials that used AVGs alone.

### Participant Characteristics

Participants were mostly community-dwelling older people. The exception was 1 trial conducted in an acute hospital setting,[28] and 2 trials that recruited from care homes.[31,33] The average age of community-dwelling participants was 75.6 (6.9) years (n = 675) and of hospitalized or nursing home older participants was 85.3 (4.5) years (n = 90).

### Inclusion and Exclusion Criteria

Thirteen trials limited inclusion to higher functioning older people[24-26,30,31,33-38,40] (ie, those with no major cardiovascular, neuromuscular, or vestibular impairments, who were independent in ambulatory function). Three trials targeted people with balance limitations or falls risk.[27,32,39] One trial did not report exclusion criteria[29] and the remaining trial recruited hospitalized older people.[28]

Twelve trials excluded those with cognitive impairment.[24-26,28,31-34,37-40] Cognitive impairment was not specified as an exclusion criterion in 1 trial, but baseline cognitive scores indicated normal cognition for all participants.[24] Cognitive status was not specified in the remaining 5 trials.[23,27,29,35,36]

### Physical Performance (Mobility) Measures

Changes in physical performance measures were assessed in 10 trials.[23,25,27,28,30,34-36,38,39] The most frequently used mobility measure was the Timed Up and Go (TUG)[41] and its modification, the 8-ft Up and Go.[42] Seven trials used the TUG[23,25,27,28,34,38,39] and 3 trials used the 8-ft Up and Go.[30,35,36]

One trial[43] used the Short Physical Performance Battery[44] and 2 trials[30,35] used the Senior Fitness Test, which includes the 30-second chair stand test.[45]

The mean baseline TUG score for trials that used this measure was 10.3 (4.1) seconds (n = 169),[23,25,27,34,38] which was within the expected range of 7 to 15 seconds for healthy older people.[46,47] The mean baseline 8-ft TUG score was 7.9 (1.6) seconds (n = 159)[30,36] which was also within the normal range for healthy older people.[48] In participants with balance and mobility limitations, baseline TUG scores were higher (20.9 (3.5) seconds; n = 30)[39] and in the only inpatient-based study,[28] baseline TUG group means were considerably higher (36.7 (18.7) seconds; n = 44).

A meta-analysis on pooled TUG scores from 6 trials (n = 206) that compared AVGs with conventional exercise or no intervention failed to reach significance (REM, MD = −2.29; 95% CI, −5.20 to 0.64).

A meta-analysis on pooled 30-second chair stand scores from 4 trials (n = 188)[27,30,35,37] showed a significant effect in favor of AVGs (REM, MD = 3.99; 95% CI, 1.92-6.05) (Figure 2). No significant effect was found for the 5 times sit-to-stand used in 1 trial.[38]

**Table 1. Study Participant and Intervention Description**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Bieryla and Dold[23] | IG | 12 | 82.6 | 1.6 | *AVGs alone*. Wii yoga (half-moon, chair, warrior), aerobic (torso twists), and balance games (soccer heading, ski jump) modes. Advanced as participants could manage | *Balance and mobility*<br>• Berg Balance Scale (BBS)<br>• Timed Up and Go (TUG)<br>• Forward Reach<br>• Fullerton Advanced Balance Scale | • Significant change in BBS pre/post for IG but not CG<br>• No significant change for other measures |
| | CG | 12 | 80.5 | 7.8 | *No intervention* | | |
| Cho et al[24] | IG | 17 | 73.1 | 1.1 | *AVGs alone*. Wii Fit ski slalom, table tilt and balance bubble | *Balance*<br>• COP eyes open and closed | • Significant improvement (reduction) in COP excursion for IG but not CG |
| | CG | 15 | 71.7 | 1.2 | *No intervention* | | |
| Duque et al[32] | IG | 30 | 79.3 | 10 | *AVGs combined with exercise.* Balance Rehabilitation Unit—combination of visual vestibular retraining (saccadic, optokinetic stimulation, vestibular optokinetic and vestibular-ocular reflex exercises performed while standing) and postural retraining using the virtual reality head set, consisting of 3 different postural training games with increasing levels of complexity, in addition to usual care | *Balance*<br>• Limits of stability (LOS) and COP using the "Balance Rehabilitation Unit"<br>• Survey of Activities and Fear of Falling in the Elderly (SAFE) questionnaire | • Significant within-group improvements in COP and LOS for the IG but no significant difference between IG and CGs. Significant improvement (reduction) in COP excursion and improvement (increase) in LOS for IG compared with CG at 9 mos for some conditions<br>• SAFE scores significantly better in IG compared with CG |
| | CG | 40 | 75 | 8 | *Usual care.* A care plan on falls prevention including an invitation to join an exercise program (after the Otago protocol) medication review, home visit by an occupational therapist, hearing and visual assessment, nutritional supplements and vitamin D supplementation as required and education materials on falls prevention | | |
| Franco et al[26] | IG | 11 | 79.8 | 4.7 | *AVGs combined with exercise.* Wii Fit balance, Individual supervised sessions plus home exercise program | *Balance and acceptability*<br>• Berg Balance Scale (BBS)<br>• Tinetti Gait and Balance Assessment (POMA)<br>• SF36 health survey<br>• Wii Fit enjoyment questionnaire-specifically developed for the study | • No significant between-group pre/post differences in BBS, POMA or SF36 scores<br>• Participants enjoyed AVGs and many preferred them to usual exercise |
| | IG | 11 | 77.9 | 6.9 | *Balance exercise.* "Matter of Balance" group exercises warm-up, strength and balance and cool down | | |
| | CG | 10 | 76.9 | 6.3 | *No intervention* | | |
| Jorgensen et al[27] | IG | 28 | 75.9 | 5.7 | *AVGs combined with exercise.* Wii Fit Balance games, leg strength and standing row squat | *Physical performance and balance*<br>• Maximal isometric voluntary contraction (MVC) of leg extensors<br>• Postural sway (COP)<br>• Timed Up and Go (TUG)<br>• Short-form Falls Efficacy Scale International (FES-1)<br>• 30-s repeated chair stand test | • Significant improvement in MVC of IG compared with CG<br>• No significant difference between groups for COP<br>• Significant between-group differences in favor of the IG for TUG, FES-1, and chair stand tests |
| | CG | 30 | 73.7 | 6.1 | Placebo insoles | | |

(*continues*)

**Table 1. Study Participant and Intervention Description (*Continued*)**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Lai et al[25] | IG | 15 | 70.6 | 3.5 | *AVGs alone*. Xavix measured step system (XMSS)—uses a step mat plus console and television | *Balance and mobility*<br>• Berg Balance Scale (BBS)<br>• Timed Up and Go (TUG)<br>• Modified Falls Efficacy Scale (MFES)<br>• Unipedal stance test<br>• Postural sway: sway area, sway velocity and COP tests | • Significant within-group improvements in BBS, TUG and MFES and Sway Velocity test for the IG. No significant within-group improvements in BBS, TUG and MFES and Sway Velocity test for the CG. Between-group comparison not reported |
| | CG | 15 | 74.5 | 4.7 | *No intervention* | | |
| Laver et al[28] | IG | 22 | 85.2 | 4.7 | *AVGs alone*. Wii Fit program set and supervised by physiotherapists delivered one to one including balance, strength and light aerobics in standing | *Balance and mobility*<br>• Timed Up and Go (TUG)<br>• Short Physical Performance Battery (SPPB)<br>• Modified Berg Balance Scale (MBBS)<br>• Timed Instrumental Activities of Daily Living (Timed IADL) test<br>• Functional Independence Measure (FIM)<br>• Activity-Specific Balance Confidence Scale (ABC)<br>• Health-related quality of life (EQ5D) | • Rate of improvement per session significantly greater in the IG than in the CG for TUG and BBS scores<br>• No significant differences were found between groups for the SPPB, Timed IADL Test, ABC Scale or EQ5D |
| | CG | 22 | 84.6 | 4.4 | *Conventional physiotherapy*. Walking balancing, transfers | | |
| Lee et al[29] | IG | 40 | 75.2 | 6.6 | *AVGs combined with exercise.* Wii Fit and Wii sports games, walking, chair stands with weighted vest and another 5-min walk | *Balance and gait parameters*<br>• Balance Efficacy Scale (BES)<br>• Gait performance parameters measured using GAITRite walkway, that is, velocity, stride length, cadence, double support time and swing time | • No significant between-group differences in BES<br>• Significant within-group differences in gait velocity, stride length, cadence, swing time and reduction in double support time but no between-group differences |
| | CG | 42 | | | *Conventional exercise*, for example, chair stands, chair lunge, heel raise, stepping, and arm curl using Thera-Bands; stretching (upper and lower body muscles) and balancing activities (stand on one leg, hold a small ball) | | |
| Maillot et al[30] | IG | 16 | 73.5 | 4.1 | *AVGs alone*. Three time periods of (i) Nintendo Wii Fit (plus balance board), in pairs, playing Wii boxing/tennis/bowling; (ii) individual Wii balance board games; (iii) a final Wii game for either balance, energy, or cognition | *Physical performance and cognitive function*<br>• Senior Fitness Test (SFT): includes chair-stand test, arm curl, 6-Min Walking Test, chair-sit-and-reach test, back-scratch test and 8-foot up-and-go test<br>• Cognitive test battery: (i) executive control tasks; (ii) visuospatial tasks; (iii) processing-speed tasks | • Significant improvement in SFT scores in favor of the IG for all measures except flexibility<br>• Significant improvement scores in favor of the IG for executive control and processing speed but not for visuospatial tasks |
| | CG | 16 | 73.5 | 3.0 | *No intervention* | | |

(*continues*)

**Table 1. Study Participant and Intervention Description (*Continued*)**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Pichierri et al[31] | IG | 15 | 86.9 | 5.1 | *AVGs combined with exercise.* Exercise program consisting of progressive resistance and postural balance training including 2 sets of 10-15 repetitions of lower limb exercises with training intensity controlled using Borg's perceived exertion scale; plus a progressive video game dancing program using a modification of Step Mania (Dance Dance Revolution) | *Balance and gait parameters*<br>• Foot placement accuracy (FPA)<br>• Gait performance parameters measured using GAITRite walkway, ie, velocity, stride length, cadence, double support time and swing time Gaze parameters<br>• Falls Efficacy Scale International (FES-IG) | • No significant difference between groups for FPA<br>• Significant between-group differences in favor of the IG for gait velocity, stride length, cadence, swing time and single support time under dual-task conditions<br>• No significant difference between groups for FES-IG |
| | CG | 16 | 85.6 | 4.2 | *Conventional exercise*. Progressive resistance and postural balance training as above | | |
| Pichierri et al[33] | IG | 9 | 83.6 | 3.4 | *AVGs combined with exercise.* Warm-up, resistance exercises with weighted vests, balance exercises, and dance video gaming using a modification of Step Mania (Dance Dance Revolution) | *Balance*<br>• Stepping reaction time tasks (SRT) using a force platform under single- and dual-task (Stroop test) conditions | • Significant between-group differences in favor of the IG SRT under dual-task conditions |
| | CG | 6 | 86.2 | 4.8 | *No intervention* | | |
| Pluchino et al[34] | IG | 12 | 70.7 | 8.5 | *AVGs alone.* Wii Fit Balance, that requires weight shifts to lay the game: soccer heading, ski slalom, ski jump, table tilt, tightrope walk, river bubble, penguin slide snowboard slalom, lotus focus | *Balance and mobility*<br>• Timed Up and Go (TUG)<br>• One-leg stance<br>• Forward Reach (FR)<br>• Tinetti Performance-Oriented Mobility Assessment (POMA)<br>• COP, dynamic posturography, postural sway test using a force platform<br>• Falls Efficacy Scale (FES) | • No significant difference between groups for TUG, one leg stance, FR, or POMA<br>• No significant difference between groups for COP measures; all groups showed a significant improvements in COP parameters over time<br>• No significant difference between groups for FES |
| | IG | 14 | 69.3 | 6.0 | Tai Chi supervised program: 12 movements using small forward and backward steps, weight transfers from 1 leg to the other, posture alignment, small knee bends and moving slowly with a gentle resistance | | |
| | CG | 14 | 76.0 | 7.7 | *Conventional exercise*. Traditional supervised balance program | | |
| Ray et al[35] | IG | 29 | 75.0 | NS | *AVGs combined with exercise.* Wii Fit Wii-balance board and weighted vests. The intervention included 15-25 chair stands while wearing the weight vest and bouts of walking for 5-10 min at a time | *Balance and physical performance*<br>• Senior Fitness Test: includes chair-stand test, arm curl, 6-Min Walking Test, chair-sit-and-reach test, back-scratch test and 8-foot up-and-go test<br>• "NeuroCom Sensory Organization Test": COP and limits of stability (LOS), postural sway under a range of conditions (control, visual, auditory and cognitive distractors) (Stroop test) | • Significant improvement in favor of IG for 8-ft up-and-go test and 30-s chair stands<br>• No significant difference between groups for COP or LOS measures; all groups showed a significant improvements in COP parameters over time |
| | IG | 40 | | | *Conventional exercise*. Group fitness strengthening exercises for lower leg and upper body strength, plus flexibility and walking | | |
| | CG | 18 | | | *Conventional exercise*. Balance using functional activities, for example, standing, stepping, and walking on a compliant surface; walking and pivoting 180°; stair walking | | |

(*continues*)

**Table 1. Study Participant and Intervention Description (*Continued*)**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Rendon et al[36] | IG | 20 | 85.7 | 4.3 | *AVGs combined with exercise.* Wii Fit Balance plus exercycle | *Balance and mobility*<br>• 8-ft Timed Up and Go (TUG)<br>• Activity-specific Balance Confidence Scale (ABC)<br>• Geriatric Depression Scale (GDS) | • Significant improvement in 8-ft TUG in favor of AVG group<br>• Significant improvement in ABS score in favor of AVG group<br>• Not significant difference in GDS |
| | CG | 20 | 83.3 | 6.2 | *No intervention* | | |
| Sato et al[37] | IG | 28 | 70.7 | 5.35 | *AVGs alone.* Balance games custom designed using Kinect motion sensor | *Balance, mobility, and gait parameters*<br>• Berg Balance Scale (BBS)<br>• Functional reach (FR)<br>• 30-s chair stand<br>• Gait performance parameters measured using 3D motion analysis (ie, velocity, stride length, cadence, double support time, and swing time) | • Significant between-group differences in favor of the IG for BBS, FR and 30-s Chair Stand |
| | CG | 26 | 68.5 | 5.47 | *No intervention* | | |
| Schoene et al[38] | IG | 19 | 77.5 | 4.5 | *AVGs alone.* Dance Dance Revolution—an open source platform with Step Mania, specifically modified, using a dance mat | *Balance and mobility*<br>• Stepping Reaction Time (SRT)<br>• Physiological Profile Assessment test (PPA) battery: (i) visual contrast sensitivity, (ii) hand reaction time, (iii) standing balance on foam, (iv) knee joint position sense, and (v) knee extension strength<br>• Timed Up and Go (TUG)<br>• 5 times sit-stand | • Significant between-group differences in favor of the IG for SRT<br>• Significant between-group differences in favor of the IG for PPA composite scores<br>• Significant between-group differences in favor of the IG for dual-task TUG scores<br>• No significant between group-differences for TUG |
| | CG | 18 | 78.4 | 4.5 | *No intervention* | | |
| Szturm et al[39] | IG | 15 | 80.5 | 6.0 | *AVGs alone.* Custom-designed weight transfer progressive balance games on a pressure mat ± sponge surface, linked to computer monitor, requiring movement of COP | *Balance, mobility, and gait parameters*<br>• Berg Balance Scale (BBS)<br>• Timed Up and Go (TUG)<br>• Activity-specific Balance Confidence Scale (ABC)<br>• Gait performance parameters measured using GAITRite walkway<br>• Dynamic balance tests performed on foam. Outcome for tests was a "Loss of Balance" score | • Significant between-group improvements in BBS scores in favor of the IG<br>• No significant within or between-group differences in TUG scores<br>• Significant within-group improvements in ABC scores in the IG the IG but not in the CG<br>• No significant within or between-group differences in gait velocity<br>• Significant within-group improvements in "Loss of Balance" scores on foam in the IG but not in the CG |
| | CG | 15 | 81.0 | 7.0 | *Conventional exercise.* Strength and balance program using Thera-Band, leg weights, cycle, weight-bearing balance exercises (eg, sit to stand, squats, and step-ups) | | |

(*continues*)

**Table 1. Study Participant and Intervention Description (*Continued*)**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Toulotte et al[40] | IG | 9 | 72.2 | 8.6 | *AVGs alone*. Wii Fit including balance board | *Balance*<br>• Tinetti balance test battery (POMA)<br>• Unipedal standing | • Significant within-group improvements in POMA scores in Exercise group, Wii group and Wii plus exercise groups<br>• No between-group differences reported<br>• Significant within-group improvements in Unipedal standing scores in exercise group, and Wii plus exercise groups. No significant change in Wii group |
| Bieryla and Dold[23] | IG | 12 | 82.6 | 1.6 | *AVGs alone*. Wii yoga (half-moon, chair, warrior), aerobic (torso twists), and balance games (soccer heading, ski jump) modes. Advanced as participants could manage | *Balance and mobility*<br>• Berg Balance Scale (BBS)<br>• Timed Up and Go (TUG)<br>• Forward Reach<br>• Fullerton Advanced Balance Scale | • Significant change in BBS pre/post for IG but not CG<br>• No significant change for other measures |
| | CG | 12 | 80.5 | 7.8 | *No intervention* | | |
| Cho et al[24] | IG | 17 | 73.1 | 1.1 | *AVGs alone*. Wii Fit ski slalom, table tilt and balance bubble | *Balance*<br>• COP eyes open and closed | • Significant improvement (reduction) in COP excursion for IG but not CG |
| | CG | 15 | 71.7 | 1.2 | *No intervention* | | |
| Duque et al[32] | IG | 30 | 79.3 | 10 | *AVGs combined with exercise.* Balance Rehabilitation Unit—combination of visual vestibular retraining (saccadic, optokinetic stimulation, vestibular optokinetic and vestibular-ocular reflex exercises performed while standing) and postural retraining using the virtual reality head set, consisting of 3 different postural training games with increasing levels of complexity, in addition to usual care | *Balance*<br>• Limits of stability (LOS) and COP using the "Balance Rehabilitation Unit"<br>• Survey of Activities and Fear of Falling in the Elderly (SAFE) questionnaire | • Significant within-group improvements in COP and LOS for the IG but no significant difference between IG and CGs. Significant improvement (reduction) in COP excursion and improvement (increase) in LOS for IG compared with CG at 9 mos for some conditions<br>• SAFE scores significantly better in IG compared with CG |
| | CG | 40 | 75 | 8 | *Usual care.* A care plan on falls prevention including an invitation to join an exercise program (following the Otago protocol) medication review, home visit by an occupational therapist, hearing and visual assessment, nutritional supplements and vitamin D supplementation as required and education materials on falls prevention | | |
| Franco et al[26] | IG | 11 | 79.8 | 4.7 | *AVGs combined with exercise*. Wii Fit balance, individual supervised sessions plus home exercise program | *Balance and acceptability*<br>• Berg Balance Scale (BBS)<br>• Tinetti Gait and Balance Assessment (POMA)<br>• SF36 health survey<br>• Wii Fit enjoyment questionnaire-specifically developed for the study | • No significant between-group pre/post differences in BBS, POMA or SF36 scores<br>• Participants enjoyed AVGs and many preferred them to usual exercise |
| | IG | 11 | 77.9 | 6.9 | *Balance exercise.* "Matter of Balance" group exercises warm-up, strength and balance and cool-down | | |
| | CG | 10 | 76.9 | 6.3 | *No intervention* | | |

(*continues*)

Table 1. Study Participant and Intervention Description (*Continued*)

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Jorgensen et al[27] | IG | 28 | 75.9 | 5.7 | *AVGs combined with exercise.* Wii Fit Balance games, leg strength and standing row squat | *Physical performance and balance*<br>• Maximal isometric voluntary contraction (MVC)of leg extensors<br>• Postural sway (COP)<br>• Timed Up and Go (TUG)<br>• Short-form Falls Efficacy Scale International (FES-1)<br>• 30-s repeated chair stand test | • Significant improvement in MVC of IG compared with CG<br>• No significant difference between groups for COP<br>• Significant between-group differences in favor of the IG for TUG, FES-1 and chair stand tests |
| | CG | 30 | 73.7 | 6.1 | Placebo insoles | | |
| Lai et al[25] | IG | 15 | 70.6 | 3.5 | *AVGs alone.* Xavix measured step system (XMSS)—uses a step mat plus console and television | *Balance and mobility*<br>• Berg Balance Scale (BBS)<br>• Timed Up and Go (TUG)<br>• Modified Falls Efficacy Scale (MFES)<br>• Unipedal stance test<br>• Postural sway: sway area, sway velocity, and COP tests | • Significant within-group improvements in BBS, TUG and MFES and Sway Velocity test for the IG. No significant within-group improvements in BBS, TUG and MFES and Sway Velocity test for the CG. Between-group comparison not reported |
| | CG | 15 | 74.5 | 4.7 | *No intervention* | | |
| Laver et al[28] | IG | 22 | 85.2 | 4.7 | *AVGs alone.* Wii Fit program set and supervised by physiotherapists delivered one to one including balance, strength and light aerobics in standing | *Balance and mobility*<br>• Timed Up and Go (TUG)<br>• Short Physical Performance Battery (SPPB)<br>• Modified Berg Balance Scale (MBBS)<br>• Timed Instrumental Activities of Daily Living (Timed IADL) test<br>• Functional Independence Measure (FIM)<br>• Activity-Specific Balance Confidence Scale (ABC)<br>• Health-related quality of life (EQ5D) | • Rate of improvement per session significantly greater in the IG than in the CG for TUG and BBS scores<br>• No significant differences were found between groups for the SPPB, Timed IADL Test, ABC Scale, or EQ5D |
| | CG | 22 | 84.6 | 4.4 | *Conventional physiotherapy*. Walking balancing, transfers | | |
| Lee et al[29] | IG | 40 | 75.2 | 6.6 | *AVGs combined with exercise.* Wii Fit and Wii sports games, walking, chair stands with weighted vest and another 5-min walk | *Balance and gait parameters*<br>• Balance Efficacy Scale (BES)<br>• Gait performance parameters measured using GAITRite walkway (ie, velocity, stride length, cadence, double support time, and swing time) | • No significant between-group differences in BES<br>• Significant within-group differences in gait velocity, stride length, cadence, swing time and reduction in double support time but no between-group differences |
| | CG | 42 | | | *Conventional exercise,* for example, chair stands, chair lunge, heel raise, stepping, and arm curl using Thera-Bands; stretching (upper and lower body muscles) and balancing activities (stand on one leg, hold a small ball) | | |

(*continues*)

**Table 1. Study Participant and Intervention Description (*Continued*)**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Maillot et al[30] | IG | 16 | 73.5 | 4.1 | *AVGs alone*. Three time periods of (i) Nintendo Wii Fit (plus balance board), in pairs, playing Wii boxing/tennis/bowling; (ii) individual Wii balance board games; (iii) a final Wii game for either balance, energy, or cognition | *Physical performance and cognitive function*<br>• Senior Fitness Test (SFT): includes chair-stand test, arm curl, 6-Min Walking Test, chair-sit-and-reach test, back-scratch test and 8-ft up-and-go test<br>• Cognitive test battery: (i) executive control tasks, (ii) visuospatial tasks, (iii) processing-speed tasks | • Significant improvement in SFT scores in favor of the IG for all measures except flexibility<br>• Significant improvement scores in favor of the IG for executive control and processing speed but not for visuospatial tasks |
| | CG | 16 | 73.5 | 3.0 | *No intervention* | | |
| Pichierri et al[31] | IG | 15 | 86.9 | 5.1 | *AVGs combined with exercise.* Exercise program consisting of progressive resistance and postural balance training including 2 sets of 10-15 repetitions of lower limb exercises with training intensity controlled using Borg's perceived exertion scale; plus a progressive video game dancing program using a modification of Step Mania (Dance Dance Revolution) | *Balance and gait parameters*<br>• Foot placement accuracy (FPA)<br>• Gait performance parameters measured using GAITRite walkway (ie, velocity, stride length, cadence, double support time, and swing time Gaze parameters)<br>• Falls Efficacy Scale International (FES-IG) | • No significant difference between groups for FPA<br>• Significant between-group differences in favor of the IG for gait velocity, stride length, cadence, swing time and single support time under dual-task conditions<br>• No significant difference between groups for FES-IG |
| | CG | 16 | 85.6 | 4.2 | *Conventional Exercise*. Progressive resistance and postural balance training as above | | |
| Pichierri et al[33] | IG | 9 | 83.6 | 3.4 | *AVGs combined with exercise.* Warm-up, resistance exercises with weighted vests, balance exercises, and dance video gaming using a modification of Step Mania (Dance Dance Revolution) | *Balance*<br>• Stepping reaction time tasks (SRT) using a force platform under single- and dual-task (Stroop test) conditions | • Significant between-group differences in favor of the IG SRT under dual-task conditions |
| | CG | 6 | 86.2 | 4.8 | *No intervention* | | |
| Pluchino et al[34] | IG | 12 | 70.7 | 8.5 | *AVGs alone*. Wii Fit Balance, that requires weight shifts to lay the game: soccer heading, ski slalom, ski jump, table tilt, tightrope walk, river bubble, penguin slide snowboard slalom, lotus focus | *Balance and mobility*<br>• Timed Up and Go (TUG)<br>• One-leg stance<br>• Forward Reach (FR)<br>• Tinetti Performance-Oriented Mobility Assessment (POMA)<br>• COP, dynamic posturography, postural sway test using a force platform<br>• Falls Efficacy Scale (FES) | • No significant difference between groups for TUG, one leg stance, FR, or POMA<br>• No significant difference between groups for COP measures; all groups showed a significant improvements in COP parameters over time<br>• No significant difference between groups for FES |
| | IG | 14 | 69.3 | 6.0 | Tai Chi supervised program: 12 movements using small forward and backward steps, weight transfers from one leg to the other, posture alignment, small knee bends and moving slowly with a gentle resistance | | |
| | CG | 14 | 76.0 | 7.7 | *Conventional exercise*. Traditional supervised balance program | | |

(*continues*)

**Table 1. Study Participant and Intervention Description (*Continued*)**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Ray et al[35] | IG | 29 | 75.0 | NS | *AVGs combined with exercise.* Wii Fit Wii-balance board and weighted vests. The intervention included 15-25 chair stands while wearing the weight vest and bouts of walking for 5-10 min at a time | *Balance and physical performance*<br>• Senior Fitness Test: includes chair-stand test, arm curl, 6-Min Walking Test, chair-sit-and-reach test, back-scratch test and 8-ft up-and-go test<br>• "NeuroCom Sensory Organization Test": COP and limits of stability (LOS), postural sway under a range of conditions (control, visual, auditory, and cognitive distractors) (Stroop test) | • Significant improvement in favor of IG for 8-ft up-and-go test and 30-s chair stands<br>• No significant difference between groups for COP or LOS measures; all groups showed a significant improvements in COP parameters over time |
| | IG | 40 | | | *Conventional exercise.* Group Fitness strengthening exercises for lower leg and upper body strength, plus flexibility and walking | | |
| | CG | 18 | | | *Conventional exercise*. Balance using functional activities, for example, standing, stepping and walking on a compliant surface; walking and pivoting 180°; stair walking | | |
| Rendon et al[36] | IG | 20 | 85.7 | 4.3 | *AVGs combined with exercise.* Wii Fit Balance plus exercycle | *Balance and mobility*<br>• 8-ft Timed Up and Go (TUG)<br>• Activity-specific Balance Confidence Scale (ABC)<br>• Geriatric Depression Scale (GDS) | • Significant improvement in 8-ft TUG in favor of AVG group<br>• Significant improvement in ABS score in favor of AVG group<br>• Not significant difference in GDS |
| | CG | 20 | 83.3 | 6.2 | *No intervention* | | |
| Sato et al[37] | IG | 28 | 70.7 | 5.35 | *AVGs alone*. Balance games custom designed using Kinect motion sensor | *Balance, mobility, and gait parameters*<br>• Berg Balance Scale (BBS)<br>• Functional reach (FR)<br>• 30-s chair stand<br>• Gait performance parameters measured using 3D motion analysis (ie, velocity, stride length, cadence, double support time, and swing time) | • Significant between-group differences in favor of the IG for BBS, FR and 30-s Chair Stand |
| | CG | 26 | 68.5 | 5.47 | *No intervention* | | |
| Schoene et al[38] | IG | 19 | 77.5 | 4.5 | *AVGs alone*. Dance Dance Revolution—an open source platform with Step Mania, specifically modified, using a dance mat | *Balance and mobility*<br>• Stepping Reaction Time (SRT)<br>• Physiological Profile Assessment test (PPA) battery : (i) visual contrast sensitivity, (ii) hand reaction time, (iii) standing balance on foam, (iv) knee joint position sense, and (v) knee extension strength<br>• Timed Up and Go (TUG)<br>• 5 times sit-stand | • Significant between-group differences in favor of the IG for SRT<br>• Significant between-group differences in favor of the IG for PPA composite scores<br>• Significant between-group differences in favor of the IG for dual-task TUG scores<br>• No significant between-group differences for TUG |
| | CG | 18 | 78.4 | 4.5 | *No intervention* | | |

(*continues*)

**Table 1. Study Participant and Intervention Description (*Continued*)**

| Study | Group | Group Size | Age | SD | Intervention Description | Outcome Measures | Outcomes |
|---|---|---|---|---|---|---|---|
| Szturm et al[39] | IG | 15 | 80.5 | 6.0 | *AVGs alone*. Custom-designed weight transfer progressive balance games on a pressure mat ± sponge surface, linked to computer monitor, requiring movement of COP | *Balance, mobility, and gait parameters*<br>• Berg Balance Scale (BBS)<br>• Timed Up and Go (TUG)<br>• Activity-Specific Balance Confidence Scale (ABC)<br>• Gait performance parameters measured using GAITRite walkway<br>• Dynamic balance tests performed on foam. Outcome for tests was a "Loss of Balance" score | • Significant between-group improvements in BBS scores in favor of the IG<br>• No significant within or between-group differences in TUG scores<br>• Significant within-group improvements in ABC scores in the IG the IG but not in the CG<br>• No significant within or between-group differences in gait velocity<br>• Significant within-group improvements in "Loss of Balance" scores on foam in the IG but not in the CG |
| | CG | 15 | 81.0 | 7.0 | *Conventional exercise*. Strength and balance program using Thera-Band, leg weights, cycle, weight-bearing balance exercises (eg, sit to stand, squats, and step–ups) | | |
| Toulotte et al[40] | IG | 9 | 72.2 | 8.6 | *AVGs alone*. Wii Fit including balance board | *Balance*<br>• Tinetti balance test battery (POMA)<br>• Unipedal standing | • Significant within-group improvements in POMA scores in exercise group, Wii group and Wii plus exercise groups<br>• No between-group differences reported<br>• Significant within-group improvements in Unipedal standing scores in exercise group, and Wii plus exercise groups. No significant change in Wii group. |
| | IG | 9 | 84.2 | 8.1 | *Conventional exercise alone*. Adapted Physical Activities (APA): muscle strength, lower limb mobility, proprioception, balance | | |
| | IG | 9 | 76.4 | 4.7 | *AVGs combined with exercise* APA and Wii Fit | | |
| | CG | 9 | 71.8 | 8.0 | Board games and TV watching | | |

Abbreviations: AVGs, active video games; CG, control group; COP, center of pressure; IG, intervention group; NS, not significant, SD, standard deviation.

**Table 2. Cochrane Risk of Bias Ratings for Included Trials**

| Study | Random Sequence Generation (Selection Bias) | Allocation Concealment (Selection Bias) | Blinding of Participants and Personnel (Performance Bias) | Blinding of Outcome Assessment (Detection Bias) | Incomplete Outcome Data (Attrition Bias) | Selective Reporting (Reporting Bias) |
|---|---|---|---|---|---|---|
| Bieryla and Dold[23] | Unclear risk | Unclear risk | High risk | High risk | High risk | Unclear risk |
| Cho et al[24] | Unclear risk | Unclear risk | High risk | Unclear risk | Unclear risk | Unclear risk |
| Duqu et al[32] | Unclear risk | Unclear risk | High risk | Low risk | Unclear risk | High risk |
| Franco et al[26] | Low risk | High risk | High risk | High risk | Low risk | Unclear risk |
| Jorgensen et al[27] | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk |
| Lai et al[25] | Unclear risk | Unclear risk | High risk | Unclear risk | Unclear risk | Unclear risk |
| Laver et al[28] | Low risk | Low risk | High risk | Low risk | Low risk | Unclear risk |
| Lee et al[29] | Unclear risk | Unclear risk | High risk | Unclear risk | Low risk | Unclear risk |
| Maillot et al[30] | Unclear risk | Unclear risk | High risk | Unclear risk | High risk | Unclear risk |
| Pichierri et al[31] | Low risk | Unclear risk | High risk | Unclear risk | Unclear risk | Low risk |
| Pichierri et al[33] | Low risk | Unclear risk | High risk | High risk | High risk | Unclear risk |
| Pluchino et al[34] | Low risk | Low risk | High risk | Unclear risk | High risk | Unclear risk |
| Ray et al[35] | Unclear risk | Unclear risk | High risk | Unclear risk | Unclear risk | Unclear risk |
| Rendon et al[36] | Unclear risk | Unclear risk | High risk | Unclear risk | Low risk | Unclear risk |
| Sato et al[37] | Low risk | Unclear risk | High risk | Unclear risk | Low risk | Unclear risk |
| Schoene et al[38] | Low risk | Low risk | High risk | Low risk | Low risk | Low risk |
| Szturm et al[39] | Unclear risk | Unclear risk | High risk | Low risk | Low risk | Low risk |
| Toulotte et al[40] | Unclear risk | Unclear risk | High risk | Unclear risk | Low risk | High risk |

## Balance Measures

Changes in direct measures of balance were assessed in 5 trials.[24,25,32,34,35] Two trials reported significant within-group differences in center of pressure (COP) in the intervention group,[24,25] but no significant difference between intervention and control (no intervention) groups. The 3 trials that compared AVGs with conventional exercise reported significant within-group differences in COP[34,35] and limits of stability[32,35] measures for both AVG and conventional exercise groups, but no significant difference between groups for COP measures. This suggests AVGs were as effective as conventional exercise at improving COP measures.[32,34,35]

Finally, 2 trials measured stepping reaction time in response to visual cues.[33,38] Both reported significant between-group differences in favor of AVGs over the control group.

Indirect measures of balance, including 1 legged standing, the forward reach test, the Berg Balance Scale (BBS),[49] and the Tinetti Performance-Oriented Mobility Assessment (the Tinetti POMA),[50] were assessed in 9 trials.[23,25,26,28,34,36,37,39,40] Five trials used the BBS,[23,25,26,37,39] 1 used a modified BBS,[28] and 3 used versions of the Tinetti POMA.[26,34,40]

The mean baseline BBS score for trials that used this measure was 51.7 (5.2) points (n = 126),[23,25,26,37] or for trials that used the Tinetti POMA,[23,34] the mean baseline score was 26.4 (0.9) points (n = 72) indicating normal balance.[50,51] For participants with limited balance and mobility, baseline BBS scores were in the low to medium fall risk category (range 37-42 points).[39]

Mean BBS scores from 3 trials in community-dwelling participants[25,26,37] (n = 105) that compared AVGs with no intervention on BBS scores were pooled for meta-analyses (Figure 3). A significant difference in favor of AVGs over no intervention was demonstrated (MD = 0.73; 95% CI, 0.17-1.29). Pooled data (n = 49) that compared active video game BBS scores with conventional exercise[26,39] also showed an effect in favor of AVGs (MD = 4.33; 95% CI, 2.93-5.73) (Figure 2). In addition, Laver et al[28] also reported a significant improvement in the modified BBS scores in hospitalized inpatients in favor of AVGs compared with conventional exercise (MD = 0.59; 95% CI, 0.02-1.16).

For trials that used the Tinetti POMA, no significant between-group changes in balance scores were reported.[26,34,40]

Other individual item balance measures used were the single-legged stance[25,34] and the forward reach test.[23,34,37] One trial reported a significant change in the forward reach score for the AVG group over the control,[37] but no significant findings were reported for the single-legged stance.

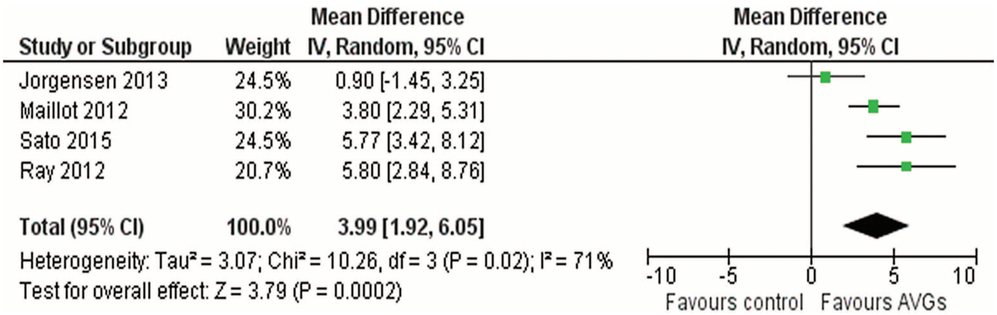


**Figure 2.** Summary of inverse variance (IV) random-effects meta-analysis examining effects of active video games (AVGs) on 30 second chair stand scores.

## Self-Report Balance Confidence Measures

Three trials used the Activities-Specific Balance Confidence Scale[28,36,39] and 5 trials used a Falls Efficacy Scale (FES).[25,27,31,34,38]

Significant change scores in favor of the AVGs were reported for the Activities-Specific Balance Confidence Scale in 2[36,39] of the 3 trials.[28]

Differences in study participants and variation in a FES used precluded combined analyses of the subjective balance measures. Of the 5 trials that used an FES, 2 showed significant between-group differences favoring AVGs[25,27] and 3 showed no significant differences between groups.[31,34,38]

## Adverse Events

Two trials monitored adverse events.[28,38] Of these, 1 reported adverse events that were minor in nature (musculoskeletal strain, feeling giddy) and occurred in both control (conventional exercise) and intervention groups.[28]

## Trial Completion and Program Adherence Rates

Trial completion rate was defined as the number of participants who completed the trial. The median trial completion rate was 89% (interquartile range, 80-100).

Program adherence was defined as the percentage of prescribed exercise sessions completed over the program duration. For the 10 trials that reported program adherence, the range was 77% to 100% in the intervention (AVG) group and 87% to 100% in the control group,[26,27,30-34,37,38,43] which is at the higher end of previously reported adherence rates for exercise RCTs.[52] On the basis of the reported reasons for participant dropouts, there was no indication that completion or adherence rates were associated with any dislike of the intervention (AVG) itself.

## Game Appeal

Five trials evaluated participants' perceptions of game appeal.[26,27,30,38,43] Of these, 4 reported positive feedback, noting that participants found AVGs to be motivating and

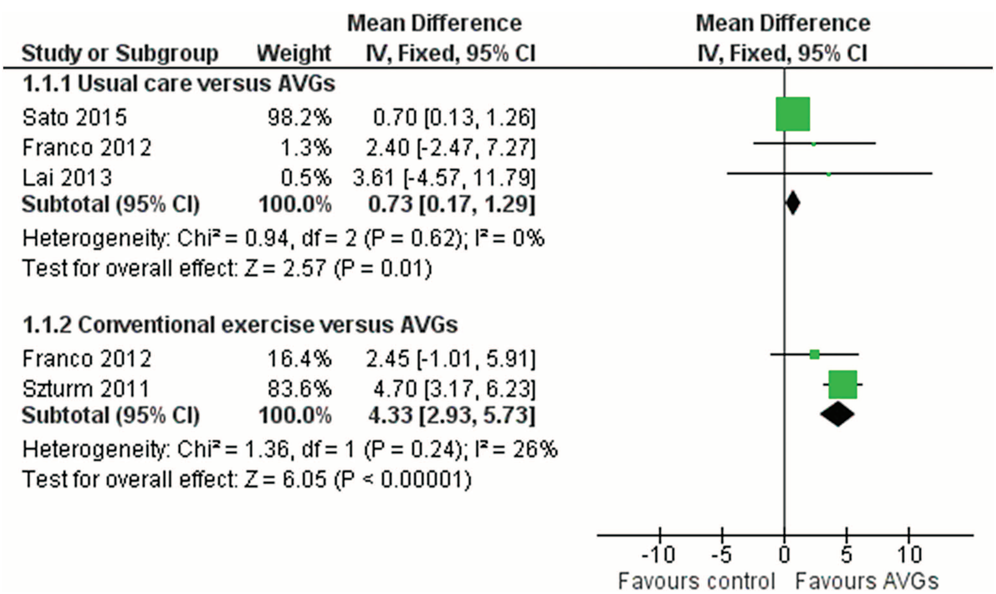


**Figure 3.** Summary of inverse variance (IV) random-effects meta-analysis examining effects of active video games (AVGs) on Berg Balance Scale sores.

enjoyable,[27,38] manageable and comparable or preferable to other physical activity.[26,30] The fifth trial, which used hospital inpatients,[28,43] reported no strong preference for the way in which their therapy was delivered before therapy commencement. However, after using the AVGs, respondents reported a preference for conventional therapy, citing they felt it to be more effective, despite having not received the other approach.[43]

## DISCUSSION

This review included 18 RCTs that compared AVGs with conventional exercise or with no intervention or usual care in older people. Active video games were found to be more effective than conventional exercise and no intervention for improving balance (BBS) and mobility (30-second sit to stand) in community-dwelling older people. In addition, the only trial that enrolled hospitalized older people reported that AVGs were more effective at improving balance and mobility scores when compared with conventional rehabilitation.

### Strengths and Limitations

This is the first systematic review of AVGs that has included a meta-analysis of RCTs for improving physical performance measures in older people. Limitations of this review include the relatively high risk of bias scores of some of the trials included in the meta-analysis. The diversity in trial design and outcome measures limited the extent to which study results could be pooled. To minimize this heterogeneity, only studies with the same outcome measures were pooled. For this reason analyses were undertaken on a small number of studies, which increased the CIs for pooled data. Furthermore, the conservative assumptions made for pooled data regarding standard deviations may have influenced the calculated effect size effects.

### Participants

Participant eligibility criteria of included trials were strict, with exclusion of people with cognitive impairment and mobility limitations, with the exception of 1 trial in an acute hospital environment.[28] Because of this, it is unclear whether AVGs are equally suitable for older people with significant cognitive impairments or with balance or mobility limitations.

Interestingly, the high baseline mobility and balance scores of participants in some trials might have masked clinically relevant improvements that may be seen in a more mobility-limited group of older people. Although the improvement in BBS scores for AVGs compared with conventional exercise shown in the meta-analyses was above the 4-point change considered clinically meaningful,[53] some trials noted that participants scored near the ceiling of the baseline balance tests, making it difficult to measure improvement.[26,27,34]

### Program Usability and Safety

With the exception of 1 trial conducted in the home environment,[38] game play was supervised and offered to individuals rather than groups. Whether participants other than high-functioning individuals could manage the AVGs without supervision has not been adequately explored. Nevertheless, there were few adverse events reported, suggesting the AVGs are safe when supervised.

The program adherence rates were good, but the intervention durations were short. Hence, the high adherence was likely related to the novelty factor; and the sustained effect of AVG use is unclear.

In terms of game appeal, community dwellers enjoyed the games. However, the hospitalized older people who received AVGs reported a preference for conventional therapy.[43] This variance of opinion may be due to both an older person's perception of using AVGs for rehabilitation, and the suitability of the game for the older person, in terms of the visual display and the ease of use of the control devices. Some trials modified the AVGs to suit the older person, in terms of reduction of onscreen information, selection of age-appropriate music, and speed of play.[31,37,54] Future development of AVGs for older people may need to consider these aspects of game play.

Lastly, whether AVGs can be used with groups rather than individuals requires investigation. Environments such as care homes do not always have the capacity to supervise individual exercise programs. On this basis, AVGs may be unsuitable for a group exercise program, unless combined with other activities as part of an activity circuit.

## SUMMARY

Active video games are a useful intervention for improving physical performance measures of balance and mobility in older people. Future work may consider monitoring adherence to an AVG program combined with conventional exercise, offered over longer period (12 months), to older people with a broader range of physical and cognitive abilities.

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